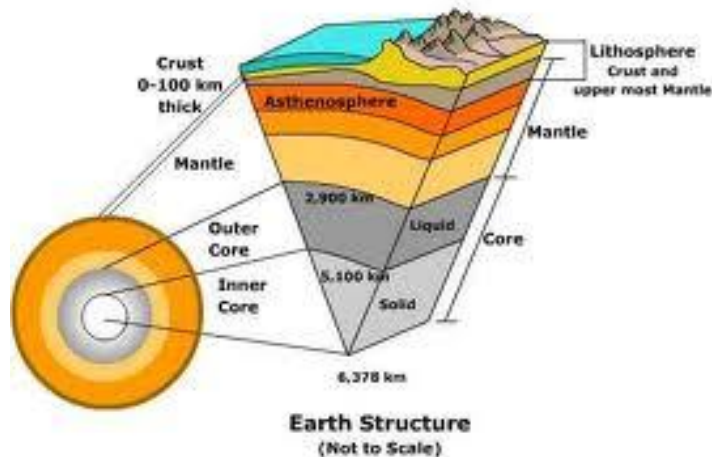


Earth Science Concepts:

(GEOLOGIC TIME SCALE)

The Atmosphere:



Why is the Earth hot inside?

- Heat from accretion (impacts).
- Differentiation (heavy stuff on Earth fall).
- Radioactive decay (they break down and give off heat).

- Troposphere: Where we live and where weather occurs. As height increases, temperature decreases. It contains 75% of gases in the atmosphere.

Earthquakes:

- Occur on plate tectonics. Happen when rocks move along fault lines and the pressure causes the rock to snap.
- P-Waves: Primary waves, they move back and forth, very fast.
- S-Waves: Secondary waves, move up and down, slower.
- Richter Scale: Measures the amount of energy released in an earthquake. Measures the height of the S-Waves.

Volcanoes:

- Found on plate tectonics, especially in the ring of fire.
- Shield volcanoes: Broad, not very tall. Not viscous lava, very runny.
- Cinder cones Steep slopes because they're built from ejected rock.
- Stratovolcanoes (Composite): Very steep, very viscous lava (thick).
- Form from divergent and *convergent* boundaries.
- Volcanoes create new crust and fertile soils.
- Release gas particles into the air (steam, CO₂, ash, dust, sulfur dioxide).

(SOLAR INTENSITY)

Weather and Climate:

- Albedo: Reflectivity of different surfaces.
- Bright things (snow) have higher albedos than darker things (ocean)

- Coriolis Effect: Phenomenon that causes fluids to curve as they travel the Earth's surface. This is because the equator moves faster than the poles so air is deflected.
 - Northern hemisphere moves winds to the right while the Southern hemisphere moves winds to the left.
- El Niño
 - Climate changes with effect the Pacific region, usually characterized by an occurrence of warm, nutrient poor water in the Pacific (Peru and Ecuador).

Requirements for life:

- Source of energy (the sun)
- Complex chemistry (RNA, DNA & CO₂)
- A liquid solvent (water)
- Protection from UV radiation (ozone layer)

Properties of Water:

- High capacity to store heat and cold
- Universal solvent
- High surface tension (moves through small openings and freezes from top down)
- Solid form is lighter than liquid form
- Polarity: Has two poles
- Water is cohesive, meaning it attracts water which is what makes a water drop
- Adhesion: Water is attracted to other substances.

Carbon Cycle:

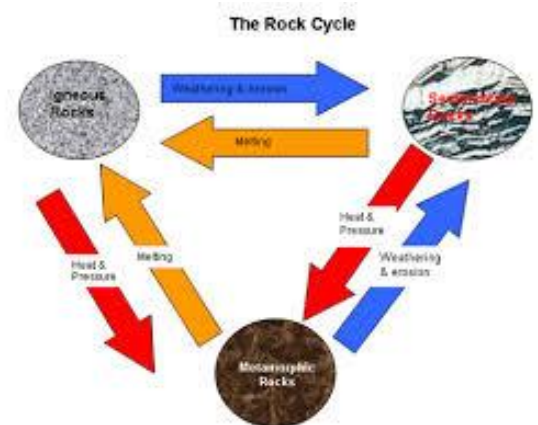
- Flux: A transfer
- Source: Donating place/area
- Sink: A receiving place/area
- Carbon in the atmosphere: Carbon dioxide.
- Carbon on land (biota, rocks, soil, fossil)
- Carbon stored in water (biota, rocks, sediments)

Rock Cycle:

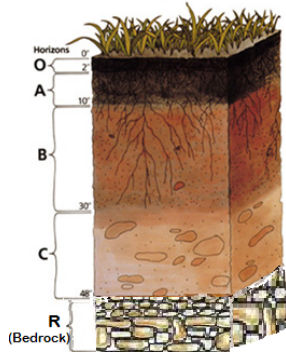
- Igneous: Formed from melting and cooling
- Sedimentary: Formed from weathering
- Metamorphic: Caused from heat and pressure

Properties and Characteristics of Soil

- Complex mixture of eroded/weathered rock, minerals, decaying organic matter, water, air and billions of organisms
- Made of
 - 45% minerals
 - 5% organic materia
 - 25% air



- 25% water
- Formed when...
 - Rock is weathered, organisms break down litter and recycle nutrients



- O → Loose, partially decayed organic matter (topsoil)
 - A → Mineral material, humus, organisms (topsoil)
 - E → Zone of eluviation/leaching
 - B → Zone of accumulation (increases by natural growth)
 - C → Weathered Rock
 - R → Rock
- *O,A,E are the zones of leeching*

- Nutrients for plants
 - N: used to make proteins, vitamins, DNA, RNA
 - P: used to make DNA, RNA, and ATP
 - K: involved in many reactions (photosynthesis)
- Provides habitat for organisms
- Anchors roots for plants
- Filters and cleans water

Ecology and Ecosystems:

Factors that impact biodiversity:

- **Habitat Destruction**
- **Invasive Species**
- **Pollution**
- **Population Growth**
- **Overharvesting**

Interactions Between Species

- Mutualism: everybody wins
 - Bees pollinating
- Commensalism: I win, you don't lose
 - Orchids growing on trees
- Competition: There is only one winner
 - competitive exclusion
- Parasitism: I win, you lose
 - mosquitoes, leeches

- Predation: I win, you die
- Indicator Species: studied to learn about the “health” of an ecosystem
 - Lichens, mollusks, oysters, mussels
- Keystone Species: large and disproportionate impact on ecosystem
 - Small in # but big effect on biodiversity
 - starfish, sea otters

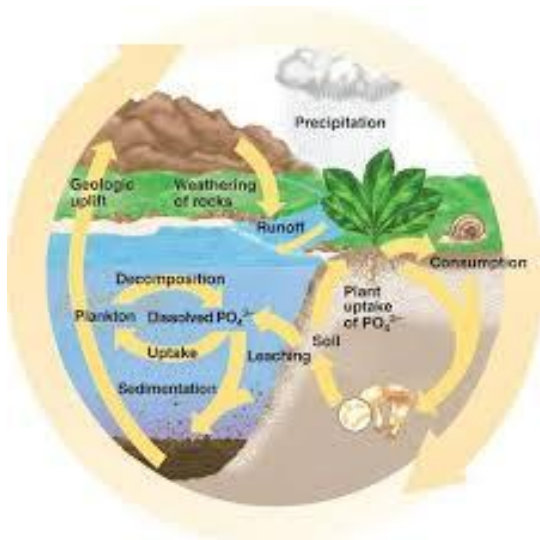
Invasive Species:

- Disrupts ecosystems
- Can out compete native species
- Disrupts food webs/food chains
- Characteristics
 - lack natural predators
 - could carry a disease
 - high reproductive rate
 - ability to migrate
 - generalists
- Feral Swine→ destroys, agricultural land, carries diseases, destroy wildlife, hurt humans
- Hydrilla→ Blocks sunlight and displaces native plants, lowers O2 levels which kills fish, obstructs swimming, fishing, boating

Nitrogen Cycle

- Nitrogen Fixation: N_2 (air) → NH_3 (ammonium)
- Nitrification: NH_3 → NO_2 (nitrate)
- Assimilation: NO_3 → DNA & Proteins
- Ammonification: Dead DNA and Proteins → NH_3 (ammonium)
- Denitrification: NO_2 & NO_3 → N_2 in the atmosphere

Phosphorus Cycle



- Rocks become sediments through weathering
- Sediments go into the ocean through runoff
- Through compaction and sedimentation they become rocks
- Sediments also go into the soil which becomes plants and animals

Phosphorus is a limiting nutrient

There is no gas form

Water Cycle

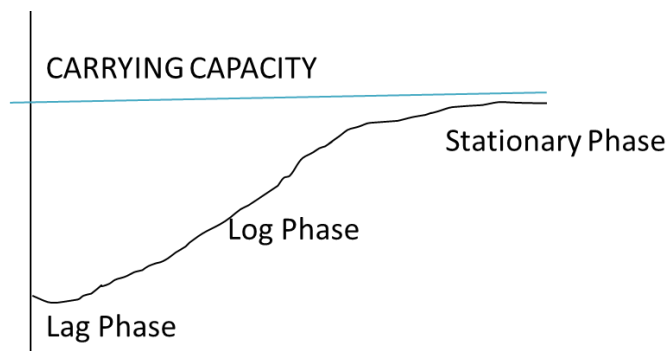


- Evaporation: occurs when the sun heats water up and it becomes vapor in the air.
- Condensation is the opposite of evaporation; it occurs when air cools and the vapor collects into liquid form.
- Precipitation: is condensation falling onto land in the form of rain, sleet, hail, snow, and mist. Only 10% of water evaporated falls as precipitation.
- Infiltration: is the downward movement of water from the land surface into the soil or porous rock. Groundwater begins as precipitation. Once water infiltrates the soil it can move vertically and horizontally through the soil.

Populations:

Carrying capacity:

- The maximum number of organisms an ecosystem can contain
- Lag phase
- Rapid growth/log phase
- Stable phase



Factors that impact human population growth:

- Factors that affect fertility/birth rate
 - Infant mortality
 - Marriage age
 - Education
 - Affluence/wealth
 - Child labor
 - Opportunities for women
 - Birth control availability
 - Religious/cultural beliefs

- Total fertility rate (TFR): Number of children a woman will bear during reproductive life.
- Replacement-level fertility: Number of children needed to replace a set of parents.
- Factors that affect death rate
 - Nutrition
 - Sanitation, water, hygiene
 - Medicine and public health

Calculating population growth - ex. doubling time, ARPC, etc.

- Annual rate of population change:
 - $ARPC = \frac{\text{birth rate} - \text{death rate}}{10}$
- Doubling time: The number of years required for a population to double (with constant growth).
- Rule of 70
 - $\text{Doubling time} = \frac{70 \text{ years}}{ARPC}$
- Crude birth/death rate:
 - $\frac{\text{Number of births/deaths}}{\text{total population}}$
- Growth rate:
 - $(\text{Birth} - \text{death}) * \text{Population Size}$
 - $\Delta N = (B + I) - (D + E)$
 - $\Delta N = (\text{Birth} + \text{Immigration}) - (\text{Death} + \text{Emigration})$

Demographic transition:

- This refers to what happens as population grows over time.
 - Stage 1: Pretransitional
 - Birth rate = Death rate which means there is no growth
 - Stage 2: Transitional
 - Birth rate stays the same while death rate decreases
 - Stage 3: Industrial
 - Birth rate decreases but the death rate stays the same
 - Stage 4: Post Industrial
 - Birth rate = Death rate which means there is no growth
 - Stage 5: Sub Replacement fertility
 - No new births and people die

Interpreting age-structure diagrams:

- The wider a diagram is, the more people live, the more population there is.

- A narrow triangle means that people are dying at young ages but there are many births
- An upside down triangle means that there aren't many births but people are living longer.

Factors limiting population growth:

- Density independent:
 - Size, crowdedness of a population does not matter
 - Examples: Food supply, climate, weather, habitat destruction
- Density dependent:
 - Size, crowdedness of a population does matter
 - Examples: Predation, disease, changes in ability to reproduce, behavioral changes.

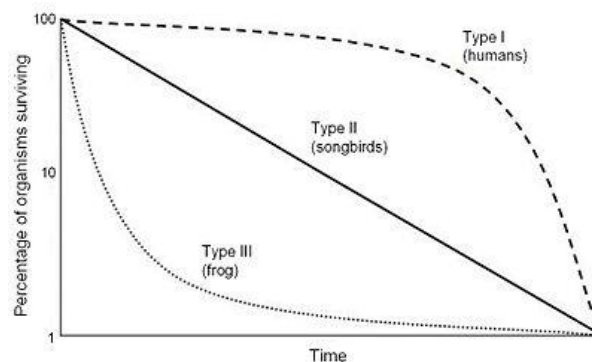
History of human population growth:

- Throughout most of history, population has been more than 1 billion
- Current population is 7.2 billion
- Projected to surpass 9 billion by 2050.
- Top 5 most populated countries:
 - China
 - India
 - U.S.A.
 - Brazil
- Thomas Malthus predicted that exponential population growth will lead to death and famine because of lack of food/resources.

R-Strategists: Have a high birth rate, many offspring and a short lifespan (Oysters and ants)

K-Strategists: Have a low birth rate, few offspring but a long lifespan (Humans).

Survivorship Curves:



Land and Water Use:

Different types of farms:

- Small tenant farms

- Farmers work for a landlord and do not own their land
- Family owned farms
- Commercial farms
 - Private, business companies.
- State owned farms

Irrigation:

- Watering land
- Flood and Furrow irrigation: Conducted by creating small parallel channels along the field length in the direction of predominant slope. Water is applied to the top end of each furrow and flows down the field under the influence of gravity. Water is lost because of evaporation.
- Spray irrigation: Sprinklers
- Drip irrigation: Saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing.
- Problem to avoid
 - Water logging (Plants drowning, roots remain underwater for too long which deprive them from getting oxygen)
 - Salinization (Small amounts of salts that naturally occur in irrigation water concentrating in soil due to evaporation .Salinity becomes toxic and the soil is no longer airable).
 - Sustainable agriculture:
 - Terracing → Grow food on a steep slope without depleting soil. This reduces runoff because they are step-like.
 - Contour planting → Planting crops across in rows rather than up and down.

Pest Management:

- Pests are undesirable competitors, parasites are predators.
- Native plants are less susceptible than non-native plants.
- Concerns with pesticides:
 - Toxicity
 - Runoff
 - Bioaccumulation/biomagnification (pesticides can be stored and build up as they move along the food chain)
- Resistance to pesticides
 - Natural selection

- Produces pesticide treadmill for farmers: Farmers have to use pesticides over and over again because the cycle becomes dependent on it.
- Integrated pest management
 - Avoid monocultures (genetically identical crops)
 - Use biological control methods which are natural predators (invasive species)
 - Use certain naturally occurring pesticides

Fishing and Aquaculture:

- Most fish come from oceans and estuaries.
- Different types of fish:
 - Bottom-dwelling
 - Open water
 - Crustaceans
 - Mollusks
- How do we catch fish?
 - Purse-seine fishing: A large purse-looking net is thrown around a school of fish and drawn.
 - Trawling: Weighted bag along bottom of sea floor which scoops fish into a net.
 - Drift net fishing: Net drags along the water, fish swim into it and get caught.
 - Hook and line: Legit fishing.
 - Pot, creels, traps: Fishers place bait on traps that are placed at the bottom of the ocean.
 - Dredging: Fishers drag a metal basket through the mud and lift it out to receive shellfish.
 - Dive catching: Divers go into the water and individually catch fish.
 - Harpooning: Stabbing fish like a fucking idiot.
 - Dynamite/Cyanide: Explosives to stun fish.
- CONS:
 - By-catch: Catching the undesired fish leads to killing non target fish.
 - Overfishing
 - Food chain disruption
- Responses:
 - Lacey Act: Bans the selling of illegally harvested animals
 - Endangered Species Act
 - Marine Mammal Protection Act

Fish Farms:

- Raising populations of fish in areas of estuaries and bays.
- Provides 1/3 of the seafood we eat.
- Pros: More sustainable, shellfish clean local waters
- Cons: Crowding, may depend upon wild fish, disease and predators

Forestry:

- Trees act as carbon sinks, prevent soil erosion, cools air, absorbs storm water, filters pollutants from air.
- Harvesting trees:
 - Clear cutting: Cutting down all trees
 - Whole tree harvesting: Removing stumps of trees
 - Strip logging: Cutting down some trees but not all
 - Selective cutting: Not cutting down all trees
 - Shelterwood cutting: Cutting down oldest trees
 - Seed tree cutting: Leaving trees that will make new trees
- Two types of trees
 - Old growth/virgin forest:
 - Trees that have never been cut down
 - Secondary forests
 - Trees that have been cut down but have come back
- Fires
 - Period fires are a natural part of a forest's life cycle
 - Allows succession to happen.

Energy:

Source:	Pro:	Con:	Other:
Coal	-Abundant energy -Cheap -Large (domestic) supply -Easy to process once mined.	-Air and water pollution (lead, mercury, sulfur). -Habitat destruction -Strip mining (mountaintop removal) -High CO2 emissions	-Bituminous contains most sulfur. It leads to acid rain and pollution. -Anthracite has the least amount of sulfur yet heats the most. -America has the most coal/ -Coal scrubbing: Removing impurities from coal before

			being burned.
Oil	-Liquid form makes it easy to transport -Burns cleaner (85% less CO2 emissions than coal). -Energy dense.	-Finite supply -Releases sulfur and mercury -Possible oil spills -Building of pipelines can affect ecosystems (ANWR). -Dependence on foreign nations (Middle East)	-Found in Middle East, Venezuela, Canada. -Oil shale is a solid, combustible mix of hydrocarbons.
Natural Gas	-Burns cleanest -60% less CO2 than coal -Reduces sulfur and nitrogen oxide emissions.	-Methane is released. -25x stronger greenhouse gas than coal. -Difficult to ship and store. -Fracking leads to environmental damage like harsh chemicals pumped in the ground, CO2, water runoff and earthquakes.	-Found where oil is.
Nuclear	-Low operating costs -Low pollution -Large power generating capacity	-Radiation contamination -Solid waste problem -Uranium is finite -Target for terrorism -Long construction time	-Ping pong effect (nuclear fission) -Fukushima, Japan: Reactor shut down. Failure of emergency cooling. -Chernobyl, Ukraine: Reactor melted. -Three Mile Island: Almost blew up.
Hydroelectric	-Uses little fossil fuel energy. -Produces little pollution -Generates a lot of electricity -Many economic	-Effects biodiversity -Large greenhouse gas emission during construction -May force people to relocate	-Three Gorges Dam

	opportunities -Flood control		
Solar	-No Pollution/greenhouse gas. -Energy is recovered.	-Expensive -Batteries must be manufactured -Life span is 20-30 years.	-Active solar power: Uses machines to circulate air/water -Passive solar power: No moving parts. -Concentrated solar power: Uses mirrors to focus water, heats water, makes steam, turns a turbine. -Different locations are better suited than others.
Wind	-Limitless and renewable -Quickly constructed/expanded -Does not take up land space	-Relies on batteries to store electricity -Note every location is suitable -Unsightly/noisey (noise pollution) -Risk to birds.	-N.I.M.B.Y
Geothermal	-Renewable, cheap and easy to install. -Low initial fossil fuel.	-Dependent on location. -Not actually renewable.	-Heat comes from under the Earth. To heat the water, then the hot water is circulated through the house as a heat source.

Pollution

AIR POLLUTION

- Cities surrounded by mountains are more likely to have smog problems.
 - Surrounding mountains prevent pollutants from being transported away
 - Los Angeles, California
- Urban heat islands
 - Temperatures in large cities are higher than surrounding areas.

- Lots of concrete and glass and lack of vegetation leads to more runoff and heat absorption.
- Tall buildings trap pollutants.

Indoor Pollution:

- Air pollutants originate within buildings and are there because of a lack of ventilation.
- Can come in through cracks or ventilation systems.
 - Secondhand smoke
 - Bacteria (which can cause pneumonia)
 - Molds (which can cause inflammation and scarring of lungs)
 - Radon Gas
 - Byproduct of radioactive decay
 - Seeps from soil and rock
 - Second most common cause of lung cancer
 - Pesticides
 - Applied to buildings to control pests but it is toxic to people.
 - Asbestos
 - Causes a particular type of lung cancer
 - Formaldehyde
 - An organic compound used in many materials found in offices and homes
 - Dust mites and pollen
 - Irritate the respiratory system

Primary Pollutants:

- What humans directly put into the atmosphere (carbon dioxide through fossil fuels, carbon, nitrogen, nitrogen dioxide and sulfur dioxide).

Secondary Pollutants:

- What is created from primary pollutants (including ozone, some sulfur dioxides, nitrogen oxides).

Sulfur Dioxide:

- Colorless and odorless gas
- Once it is emitted it can be converted to sulfate
- Causes acid rain and snow
- Can change pH and make things more acidic
- Removed from atmosphere through wet/dry deposition

Nitrogen Oxides:

- Yellow-brown/reddish-brown gas which contributes to smog
- Emitted in two forms (nitrogen oxide or nitrogen dioxide)
- Nearly all nitrogen dioxide emitted from humans.
- Reacts with cells, destroys proteins and can be acidic
- Contribute to smog

Acid Deposition

- Primary pollutants or sulfur dioxide, nitrogen oxide combined with water to produce acids.
 - Sulfuric acid and nitric acid which can travel thousands of miles.
- Tall smokestacks reduce local air pollution but can increase regional pollution

Scrubbing:

- The process by which acid rain and pollution is reduced.
- While coal is burned, power plants try to remove some sulfur dioxide by throwing lime or water in it.

Carbon monoxide:

- Colorless, odorless gas
- Even at low concentrations, it is extremely toxic to humans because it binds to hemoglobin in the blood.
- 90% comes from natural sources.
- 10% comes from fires, cars and the incomplete burning of organic compounds.

Ozone:

- In the troposphere, it kills leaf tissue at high concentrations and damages eyes and the respiratory system.
- CFCs cause ozone destruction (found in aerosol cans and the gas and fridges)
- In the stratosphere, it protects against UV radiation (most of UVB and all of UVC but does not protect against UVA)
- UVC splits up the CFC releasing chlorines and the following reactions happen:
 - $\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2$
 - $\text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2$
 - Reactions occur in the stratosphere
- Chlorine destroys ozone molecules
- Nitrogen dioxide and sunlight react makes ozone
 - $\text{NO}_2 + \text{light} \rightarrow \text{NO} + \text{O}$
 - $\text{O} + \text{O}_2 \rightarrow \text{O}_3$
 - Ozone is a colorless gas with a sweet odor
- The less ozone there is...
 - The more ozone, the more cancer, cataracts, immune system disorders, immune system disorders.
 - Decreased photosynthesis due to cellular damage
 - Damages the food chain
- Montreal Protocol
 - Outlined plan for the eventual emission of global CFCs to 50%.
 - Elimination of the production of CFCs by 1999.

Hydrocarbons:

- Aka VOC's
 - Volatile organic compounds
- Used as solvents in industries (dry cleaning, degreasing and graphic arts)
 - Pesticides (DDT)
- It can be harmful to plants and animals, can be converted to harmful compounds through reactions in the atmosphere.

Particulate Matter:

- Dust, ash, soot, lint, smoke, pollen and spores
 - Solid or liquid particles suspended in gas
- Very fine particulates are the greatest concern (easily inhaled and absorbed into the bloodstream)
- Linked to lung cancer, bronchitis, dangerous for old folks.

Lead:

- Toxic
- Damages nervous system
- Constituents of auto batteries and was once added to gasoline
- 98% reduction since 1970s.
- E-Waste

SOLID WASTE MANAGEMENT

- We throw out paper, food scraps and plastic the most
- On-site disposal: Installed in a kitchen sink, the garbage is ground and flushed into sewer systems. Must be disposed once it reaches the treatment plant.
- Composting: Bacteria and fungi break down garbage.
- Incineration: Combustible waste is burned at high temperatures can be used to produce electricity.
 - Produces air pollution, nitrogen and sulfur oxides, toxic ash and heavy metals (lead)
 - In modern incineration facilities, smokestacks are fitted with devices that trap pollutants.
 - Materials to be burnt can be sorted, but it's expensive.
- Open dumps: (Banned in the U.S.)
 - Solid waste is disposed in open landfills without regard to health/safety.
- Sanitary landfills: Designed to concentrate and contain without creating a nuisance or hazard to public safety.
 - Leachate is the most hazardous
 - Noxious, mineralized liquid capable of transporting bacterial pollutants
 - Goal is to minimize leaching
- Resource Conservation and Recovery Act (RCRA)

- Sets standards for landfills and disposal facilities and prohibits open dumping
- Identifies hazard wastes and their life cycles
- Cradles to grave management (assigns guidelines about who manufactures, transports and disposes of hazardous wastes).
- Comprehensive Environmental Response Compensation and Liability Act (CERCA)
 - Defines policies and procedures to respond to the release of hazardous substances into the environment.
 - Established liability for corporations responsible for hazardous waste sites.

WATER POLLUTION

- Measures of water quality
 - Temperature
 - Dissolved oxygen
 - pH
 - Nutrients
 - Turbidity
 - Bacteria count
 - Biological sample
- Based on intended use of water, how far the water departs from the norm, its effect on public health and its ecological impacts, there are two types of pollution:
 - Point-source: Directly into the water
 - Non-Point source: Indirect, from fertilizers (runoff)
- Water pollution causes less photosynthesis because there is less oxygen and murky waters.
- Clean Water Act: We should be able to swim and fish in all waters but only $\frac{1}{3}$ of the water in the nation is swimmable.
- Primary treatment: Filter the water
- Secondary treatment: All the sludge that settles at the bottom gets decomposed.
- Advanced Water treatment: Removes specific water pollutants.